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(54) [Title of Invention] Pneumatic radial tire which is reinforced with organic fiber cord

(57) [Abstract]

[Objective] To improve both of the vibration riding comfort performance and operational stability performance in the compatible way

[Constitution] Carcass ply is reinforced with the poly ethylene naphthalate cord having specific hot elongation and also the cap belt is reinforced with an organic belt having specific heat shrinkage stress.

[Claims of the Patent]

[Claim 1] Pneumatic radial tire which is reinforced with organic fiber cord, the tire being characterized by comprising

the carcass ply reinforced with the fiber cord which is made of poly ethylene naphthalate whose elongation under a load of 5 g/ de at 170 ± 2 deg C is in the range of 3.0 ~ 6.2 % and

the cap belt which is positioned in the belt reinforcing layer at the outermost layer of tire and is reinforced with organic fiber cord whose heat shrinkage stress at 170 ± 2 deg C is over 0.40 g/ de.

[Detailed Description of the Invention]

[0001]
[Field of Application in Industry] This invention is related to the pneumatic radial tire which is reinforced with organ-

ic fiber cord. In particular, it is related to the pneumatic radial tire which has characteristic features in the reinforcing cords of carcass ply and cap belt.

[0002]
[Existing Technology] In the past, to achieve improvement in the vibration riding comfort performance and operational stability performance, there were cases in which the physical properties of tire carcass ply were prescribed. Examples are : In the case where the vibration riding comfort performance was regarded important, the low modulus cord like nylon cord was used to lower the modulus and absorb the vibration from the road face; on the other hand, when the operational stability performance was regarded important, the high modulus cord such as polyester was used to increase the modulus and enhance the rigidity of tire. In such methods, one can not achieve sufficiently compatible improvement of both the vibration riding comfort performance and the operational stability performance. For the compatible improvement of both of these, there was the case of attempting the designing of the shape of stress- elongation curve of the carcass poly cord.

[0003]
[The Problem Which the Invention Intends to Solve] In the above described attempts, however, attention was focused only to the carcass ply cord and so there was a limit to the improvement of the vibration riding comfort performance and the operational stability performance together. Objective of this invention is to achieve further improvement of the vibration riding comfort performance and the operational stability performance together by investigating the combination of both of the carcass ply cord and the cap belt cord.

[0004]
[The Means for Solving the Problem] To achieve the above described objective, this invention has the following constitution. It is the

pneumatic radial tire which is reinforced with organic fiber cord, the tire being characterized by comprising

the carcass ply reinforced with the fiber cord which is made of poly ethylene naphthalate whose elongation under a load of 5 g/ de at 170 ± 2 deg C is in the range of 3.0 ~ 6.2 % and

the cap belt which is positioned in the belt reinforcing layer at the outermost layer of tire and is reinforced with organic fiber cord whose heat shrinkage stress at 170 ± 2 deg C is over 0.40 g/ de.

[0005] In other words, this invention provides the pneumatic radial tires which has both of the vibration riding comfort performance and the operational stability performance of high level by using the combination of the following components:
In the carcass ply, specific poly ethylene naphthalate cord with which the tire shape control is easy and also the mldulus is kept high after the vulcanization is used in the reinforcing. The characteristics of this cord is defined by the degree of hot elongation corresponding to the heat and tension which are applied to the tire at the time of making tire.
In the cap belt, in order to optimize the tire shape and also to achieve the effect of enhancing the circumferential tension of the tire, the cord having high heat shrinkage stress is used for the reinforcement.

[0006] Thus, in the past, attention was paid only to the physical properties of the carcass ply cord and so the characteristic features of cord could not be brought out sufficiently. However, by the combined use of the cord having high heat shrinkage stress in the cap belt, the true value of the said carcass ply could be exhibited and so the vibration riding comfort performance and the operational stability performance could be improved remarkably.

[0007]
[Action] In the constitution of this invention, the elongation under 0.5 g/ de at 170 ± 2 deg C of the poly ethylene naphthalate cord which is used in the carcass ply is in the range of 3.0 ~ 6.2 %. This is for the following reasons: if this is less than 3.0 %, the operational stability performance improves but the vibration riding comfort performance stays at the existing level ; on the other hand, if it exceeds 6.2 %, only the vibration riding comfort performance improves and the operational stability performance stays at the existing level. Also, preferably, it is in the range of 3.4 ~ 5.8 % and, by this, the above said performance can be achieved at higher level.

[0008] The technological reason for this is that, in the process of making the tires, the modulus change by the heat which is received by the carcass ply, i.e. the change of elongation of the cord at high temperature, affects the tire shape greatly. When this gets out of the above said range, the antinomy of the vibration riding comfort performance and the operational stability performance becomes stronger.

[0009] Also, the reason for using the poly ethylene naphthalate cord for reinforcing this carcass ply is to keep the modulus of the carcass cord in the tire after the tire making, i.e. after the product of tire is made, at a higher level than that of the existing product (e.g. poly ethylene

terephthalate). By using this, the rigidity of tire improves remarkably and, in particular, the level of response or linearity in the evaluation of the operational stability of tire improve ; also, in the vibration riding comfort performance, the level of settlement of vibration and shock improves.

[0010] Also, if the heat shrinkage stress at 170 ± 2 deg C of the cord which is used in the cap belt is less than 0.40 g/de, the above said improvement of tire performance can not be achieved even if the poly ethylene naphthalate cord which is due to this invention is used at the carcass ply. Only when the organic fiber cord of the polyamide cord having a large heat shrinkage stress is used in the cap belt, the tire performance improves remarkably.

[0011] This is due to the fact that, when the cap belt having a high heat shrinkage stress is used, a tightening force works in the circumferential direction of the whole tire tread at the time of tire making and the shape of the ground-contact surface is flattened. It is believed that, by this flattening, the effect on the vibration riding comfort performance and the effect on high operational stability performance by the improvement of rigidity in the circumferential direction of the tread section are satisfied simultaneously.

[0012] In this case, the upper limit value is not particularly specified for the heat shrinkage stress of the reinforcing cord of cap belt. But, when polyamide, for example is used as the cap belt, normally it can be raised only up to about 0.65 g/ de and, when it is tried to raise this above this level, deformation of tire occurs at the time of making the tire and, in the common method of tire making, the uniformity of tire is lost. Therefore, preferably, it is in the range of 0.40 ~ 0.65 g/ de, more preferably 0.43 ~ 0.60.

[0013] As for the type of cord for the cap belt, any one is good as long as it has a high heat shrinkage stress and has the adhesive strength which can endure the elevated temperature of the tread section for durability. Examples are : Poly amide cord, poly ester cord, poly aramid cord, hybrid cord of poly ester and poly amide (twisted together), conjugated cord of poly ester and poly amide (core - shell structure).

[0014] Test method

(a) Method of measuring elongation under a load of 0.5 g/de at 170 ± 2 deg C.

Using the tensile testing machine attached with a constant temperature tank at the atmospheric temperature of 170 +- 2 deg C, test was conducted under JIS L1017. On an autograph, the stress (g/de) - elongation (%) curve was drawn and the elongation under the stress of 0.5 / de was read out. Here, 0.5 g/de is the tension which is believed to be applied to a piece of the ply cord at the time of vulcanization.

[0015] Method of measuring the heat shrinkage stress at 170 ± 2 deg C.

At the room temperature (25 ± 2 deg C), an initial load of 1/60 g/ de (0.0167 g/ de) for the total denier of cord was applied to the cord and this state was fixed. After this, the atmospheric temperature of the cord was raised at a rate of 5 deg C/ min up to 170 ± 2 deg C. At the time point when 170 ± 2 deg C was reached, the stress (g/ de) generat- ed by the heat shrinkage of the cord was taken as the heat shrinkage stress (g/ de) at 170 ± 2 deg C.

[0016] The testing machine for this measurement needs to have a constant temperature tank in which the temperature can be raised at a rate of 5 deg C / min in the range of about 20 ~ 200 deg C and it needs to have the capability of measuring the stress in the range of 20 ~ 6000 g which is applied to the cord.

[0017] Method of making the poly ethylene naphthalate which is due to this invention.

The raw yarn which was made from the poly ethylene -2,6 - naphthalate is given the primary twist and 2 pieces of these are put together and the final twist is applied. At this time, for the final twist factor α, the optimal value is sel-ected in the range of $0.30 < \alpha < 0.60$.

[Mathematical equation 1]

(In the equation, N is the number of twists per 10 cm of the cord, D is 1/2 of the total denier of the cord and P is the specific gravity of the fiber).

[0018] To the cord which is obtained in this manner, the adhesive heat treatment is conducted under the following conditions. First the cord is dipped in the adhesive which is based on the resorcin - formaldehyde - latex. The drying heat treatment is conducted as follows. Treatment tempera- ture in the drying zone is 170 deg C and the treatment time is 60 ~ 160 seconds. Also, for the heat setting zone and normalizing zone, the treatment temperature is 250 ~ 260 deg C, respectively. and the treatment time is 60 ~ 160 seconds,

respectively. Further, in the heat setting zone, the cord tension is 0.10 ~ 1.20 g/ de, and the cord tension in the normalizing zone is set in the range of 0.03 ~ 0.50 g/de. By this treatment, the cord of desired physical properties can be obtained.

[0019] Also, as for the type of cord of the cap belt, any one which has a high heat shrinkage stress and has the adhesive strength which can withstand the elevated temperature of the tread section for durability is good. For example, 6,6 - nylon is suitable as the material.

[0020] For example, in the case of using 6,6 - nylon, it is obtained by the following method of making. Thus, the 6,6 - nylon raw yarn which was made by the common method of making is given the primary twist and 2 pieces of this are put together and then the final twist is applied. At this time, as for the final twist factor α, the optimal value is selected in the range of $0.30 < \alpha < 0.60$ (α satisfies the relation of previously shown equation 1).

[0021] To the cord which is obtained in this manner, the adhesive heat treatment is conducted under the following conditions. First the cord is dipped in the adhesive which is based on the resorcin - formaldehyde - latex. The drying heat treatment is conducted as follows. Treatment temperature in the drying zone is 170 deg C and the treatment time is 60 ~ 120 seconds. Also, for the heat setting zone and normalizing zone, the treatment temperature is 230 ~ 245 deg C, respectively. and the treatment time is 60 ~ 120 seconds, respectively. Further, in the heat setting zone, the cord tension is 0.70 ~ 1.90 g/ de, and the cord tension in the normalizing zone is set in the range of 0.35 ~ 0.90 g/de.

[0022] Characteristic feature of the cap belt cord in this invention is the high heat shrinkage stress. So, for its characteristic feature to be exhibited, it is necessary to conduct the treatment at a somewhat lower temperature and also higher tension than the existing dry heat treatment method.

[0023]
[Examples of Application] In the following, the invention is explained on the basis of the examples of application. The size of tires which were used had the tubeless structure of 205/ 65R15 and the tire was made at the normal condition in the factory.

[0024] As to the carcass ply, 1500 D/ 2 (1500 denier 2 yarns twisted), primary twist x final twist numbers were 39 x 39 (times/ 10 cm); 2 sheets were placed at the angle of 80 ~ 90 deg with respect to the circumferential direction (in actual

application, 90 deg for both), and the density of placement was 50 ea/ 5 cm.

[0025] As to the belt layer, 2 sheets of steel cord belt of 1 x 5 x 0.23 construction were placed and the placing angle was 26 deg left and right, respectively, relative to the circumferential direction and the density of placement was 55 ea/ 5 cm.

[0026] As to the cap belt, 1260 D/ 2 (1260 denier 2 yarns twisted), primary twist x final twist number was 39 x 39 (ea/ 10 cm); 1 sheet was placed at an angle of placement of 0 ~ 15 deg with respect to the circumference (in actual application, 0 deg) and the density of placement was 55 ea. / 5 cm.

[0027] Table 1 shows the type and physical properties of each cord which was used in the tire and the tire performance. Thus, Comparative Examples 1 ~ 3 are the cases in which poly ethylene terephthalate (PET) was used as the carcass ply reinforcing cord. Comparative Examples 4 ~ 6 and Examples of Application 1 ~ 8 are the cases in which poly ethylene naphthalate (PEN) was used. As for the cord for the reinforcement of cap belt, nylon 6,6 cord (NY 66) was used in all of the comparative examples and examples of application.

[0028] Tire performance test methods were as follows.

Operational stability test

The trial tires were mounted to the passenger car and, at the speed of 60 ~ 200 kg/ h, actual vehicle feeling tests were conducted and, for each item such as (1) straight run stability, (2) cornering stability, (3) rigidity feeling, (4) handling, an evaluation by 1 ~ 10 points were conducted and, the average point of evaluation of the whole items was determined. The tests were conducted by two professional drivers; average of the evaluation points by two persons was obtained. Taking Comparative Example 1 as the control (100), the results were indicated by the indices. A larger numerical value is the good ones.

[0029] Vibration riding comfort performance

Each trial tire was mounted on a passenger car and the feeling test of vibration riding comfort performance was conducted by 2 professional drivers. Evaluation points of 1 ~ 10 were given and, with the average of the two persons, result was indicated by indices with the Comparative Example 1 taken as control (100) as in the previously described case.

A greater numerical value is better.

[0030] [Table 1]

			C1 比較例1	C2 比較例2	C3 比較例3	C4 比較例4	C5 比較例5	C6 比較例6
1	カーカスプライ	繊維種	PET	PET	PET	PEN	PEN	PEN
2		170 ℃における0.5g/de荷重下の伸度 (%)	2.8	5.3	5.3	2.8	8.4	5.3
3	キャップベルト	繊維種	NY66	NY66	NY66	NY66	NY66	NY66
4		170 ℃における、熱収縮応力 (g/de)	0.38	0.38	0.43	0.43	0.43	0.38
5	タイヤ性能	振動乗心地性能 (指数)	100	105	107	98	117	109
6		操縦安定性能 (指数)	100	94	96	118	92	98

			E1 実施例1	E2 実施例2	E3 実施例3	E4 実施例4	E5 実施例5	E6 実施例6	E7 実施例7	E8 実施例8
1	カーカスプライ	繊維種	PEN	PEN	PEN	PEN	PEN	PEN	PEN	PEN
2		170 ℃における0.5g/de荷重下の伸度 (%)	3.0	3.4	4.5	5.3	5.3	5.3	5.8	8.2
3	キャップベルト	繊維種	NY66	NY66	NY66	NY66	NY66	NY66	NY66	NY66
4		170 ℃における、熱収縮応力 (g/de)	0.43	0.43	0.43	0.40	0.42	0.45	0.43	0.43
5	タイヤ性能	振動乗心地性能 (指数)	106	112	116	114	118	121	119	120
6		操縦安定性能 (指数)	117	116	112	109	106	110	108	102

C1. Comparative Example 1; E1. Example of Application 1;
1 ~ 2. Carcass ply; 1. Fiber type; 2. Elongation under 0.5 g/de load (%) at 170 deg C;
3 ~ 4. Cap belt; 3. Fiber type; 4. Heat shrinkage stress (g/de) at 170 deg C ;
5 ~ 6. Tire performance; 5. Vibration riding comfort performance (index); 6. Operational stability performance (index)

[0031] In the results of Table 1, when poly ethylene terephthalate cord was used in the carcass ply, the operational stability performance was low even if the hoot elongation and cap belt cord were in the range of this invention (Comparative Example 3). Also, even when poly ethylene naphthalate was used, the vibration riding comfort performance (Comparative Example 4) or the operational stability performance (Comparative Example 5) were inferior when the hot elongation was outside the specification. Even if only the carcass ply cord is within the specification, the operational stability performance is not good if the cap belt does not satisfy the condition (Comparative Example 6). In con-

trast to this, in Examples of Application 1 - 6, both of the two performance are good.

[0032]
[Effectiveness of the Invention] When this invention is used, when the cords which are due to this invention are used both for the carcass ply and cap belt, both of the vibration riding comfort performance and the operational stability performance can be maintained to high level together compatibly.